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(71) Applicant: SAMSUNG ELECTRONICS CO., LTD.
Suwon-City, Kyungki-do (KR)

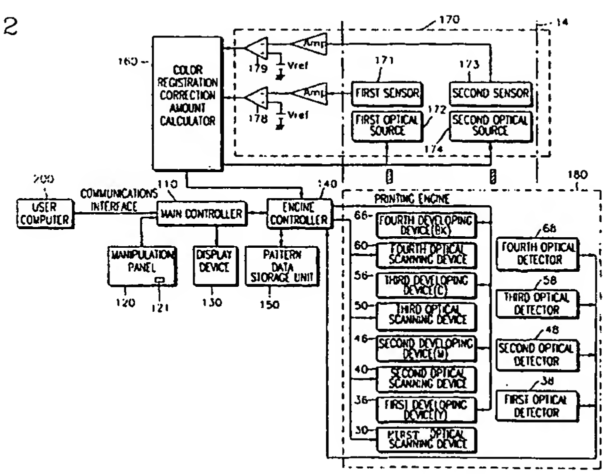
(72) Inventors:
- Eom, Yoon-seop
Jangan-gu, Suwon-city, Kyungki-do (KR)
- An, Seung-deog
Suji-eup, Yongin-city, Kyunkgi-do (KR)
- Kim, Nam-ryoung
Paldal-gu, Suwon-city, Kyungki-do (KR)
- Park, Sang-shin
Paldal-gu, Suwon-city, Kyungki-du (KR)
- Lee, Beom-ro
Seodaemun-gu, Seoul (KR)

(74) Representative: Robinson, Ian Michael
Appleyard Lees,
15 Clare Road
Halifax HX1 2HY (GB)

(54) **Printer and method of correcting color registration error thereof**

(57) A printer wherein test patterns for each optical scanning device (30,40,50,60) set to detect the color registration error between the optical scanning devices can be formed on a photoreceptor (14). The printer includes a pattern position detection means (170) for detecting the positions of the test patterns formed from fixed positions through a developing process, and a color registration correction means (160) for calculating a color registration error amount from the position information of the test patterns provided by the pattern position detection means, and for calculating color registration correction data from the calculated error amount and outputting the calculated correction data to an engine controller (140). In color registration error correction using the printer, the positions of electrostatic latent images, corresponding to test patterns formed on a photoreceptor belt by each of optical scanning devices (e.g. yellow, magenta and cyan), are detected by developing the electrostatic latent images with a single color (e.g. black). Therefore, a structure for measuring error amounts from the test patterns is simple, and the accuracy of measurement can be improved.

FIG. 2



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Description

[0001] The present invention relates to a printer designed to be able to correct registration of images of different colors at wrong areas, and a method of correcting a color registration error.

[0002] Referring to Figure 1 showing a cross-sectional view of a general liquid electrophotographic printer, a reset device 15, optical scanning devices 30, 40, 50, 60, optical detectors 38, 48, 58 and 68, developing devices 36, 46, 56 and 66, a drying device 18, and a transfer device 20 are installed around the circulation path of a photoreceptor belt 14 circulating by means of and around a plurality of rollers 11, 12 and 13. Reference numeral 15a is an exposing device for erasing an electrostatic latent image, and reference numerals 15b, 37, 47, and 57 are chargers for charging the photoreceptor belt 14 with a predetermined potential to have a photoreceptor belt on which a new electrostatic latent image can be registered.

[0003] In a printing process, first, when the leading end of an image writing page area determined on the photoreceptor belt 14 reaches the scanning position of the first optical scanning device 30, the first optical scanning device 30 projects light corresponding to yellow image information. An electrostatic latent image formed on the photoreceptor belt 14 by the first optical scanning device 30 is developed by the first developing device 36 for supplying a yellow developer (Y). The page area on the photoreceptor belt 14 is charged by the charger 37 so that a new electrostatic latent image can be written onto the page area. Next, when the charged page area reaches the scanning position of the second optical scanning device 40, the second optical scanning device 40 projects light corresponding to magenta-color image information. Another electrostatic latent image formed on the photoreceptor belt 14 by the second optical scanning device 40 is developed by the second developing device 46 for supplying a magenta color developer (M).

[0004] Such a process is continued through the third and fourth optical scanning devices 50 and 60 for projecting cyan-color image information and black image information, and through the third and fourth developing devices 56 and 66 for supplying a cyan-color developer (C) and a black developer (BK). Consequently, a color image is formed on the photoreceptor belt 14 passed through the fourth developing device 66. The color image formed of a developing material on the photoreceptor belt 14 is first transferred to a transfer roller 21 whose part rotates in contact with the photoreceptor belt 14, via the drying device 18 for removing liquid carrier. The color image transferred to the transfer roller 21 is then transferred to a sheet of paper 23 entering between the transfer roller 21 and a fixing roller 22.

[0005] In this printer, when the optical scanning devices 30, 40, 50 and 60 sequentially write respective color image information, to be written on the same page, on the proceeding photoreceptor belt 14, if the respective color image information are registered at wrong areas, a desired image cannot be obtained. Color registration error means that different color images are not registered at correct pixel writing positions on the photoreceptor belt 14.

[0006] In order to correct this color registration error, in the prior art, the image of a predetermined test pattern is commanded to be printed, and an inspector measures the distance difference between adjacent test patterns of different colors output on the paper 23 to calculate the amount of color registration error. However, this method is complicated in that the inspector must manually calculate the color registration error, and has a high possibility of artificial errors being included during the calculation of the error amount. In contrast, there is a method in which test patterns for each color are printed using all of the developing devices 36, 46, 56 and 66 by a normal printing method, and the amount of color registration error is calculated by detecting information associated with the interval between the printed test patterns of different colors using an image information acquisition sensor such as a CCD. However, image information acquisition sensors for respective colors must be installed to accurately measure a color registration error using this method, thus complicating the installation.

[0007] It is an aim of the present invention to provide a printer which can internally and accurately measure and correct a color registration error without adding a large number of components, and a method of correcting the color registration error.

[0008] According to the present invention there is provided a printer as set forth in claim 1 appended hereto. Also according to the present invention there is provided a method as set forth in claim 6 appended hereto. Preferred features of the invention will be apparent from the dependent claims and the description which follows.

[0009] In one aspect of the present invention there is provided a printer comprising; a photoreceptor circulating along a path formed by a plurality of rollers; a plurality of optical scanning devices for scanning light toward the photoreceptor; a plurality of developing devices for supplying developing materials of different colors to the photoreceptor; a plurality of detectors for detecting part of light emitted from the optical scanning devices; an engine controller for controlling the driving of the optical scanning devices, the developing devices, and the rollers using received light output from the optical detectors so that test patterns for each optical scanning device set to detect the color registration error between the optical scanning devices can be formed on the photoreceptor; a pattern position detection means for detecting the positions of the test patterns formed from fixed positions through a developing process; and a color registration correction means for calculating a color registration error amount from the position information of the test patterns provided by the pattern position detection means, and calculating color registration correction data from the calculated error amount and outputting the calculat-

ed correction data to the engine controller.

[0010] Preferably, the pattern position detection means comprises: first and second pattern position detection sensors spaced apart from each other opposite to an image writing surface of the photoreceptor; and first and second optical sources for irradiating light toward the detecting areas of the first and second pattern position detection sensors.

[0011] Preferably, the pattern position detection means comprises: first and second pattern position detection sensor spaced apart from each other opposite to a transfer device for transferring an image formed on the photoreceptor to paper; and first and second optical sources for irradiating light toward the detecting areas of the first and second pattern position detection sensors.

[0012] Preferably, a cleaning device for cleaning the completely-developed test patterns is installed at a predetermined position on an image transmission path.

[0013] According to a second aspect of the present invention there is provided a color registration error correcting method for use in a printer having a photoreceptor circulating along a path formed by a plurality of rollers, a plurality of optical scanning devices for scanning light toward the photoreceptor, and a plurality of developing devices for supplying developing materials of different colors to the photoreceptor, the method comprising the steps of: (a) forming electrostatic latent images corresponding to test patterns of different colors set for color registration error detection, on the photoreceptor by the optical scanning devices; (b) developing the different color electrostatic latent images with a single color developing material by one selected developing device; (c) detecting the positions of the test patterns formed of the single color developing material; (d) calculating color registration error amounts from the detected test pattern position information; and (e) obtaining color registration correction data from the error amounts calculated in step (d).

[0014] Preferably, the method further comprising repetition of steps (a) through (d) with the correction data obtained in step (e).

[0015] Preferably, the test patterns are set to be aligned on the image writing start and close positions corresponding to the both ends of an image writing area set in the middle portion of the photoreceptor, and predetermined intervals apart from each other along the traveling direction of the photoreceptor.

[0016] Preferably, the test patterns comprise: first reference test patterns spaced apart from each other at predetermined intervals along the sub-scan direction on the main-scan directional image writing start position corresponding to one end of the image writing area set in the middle portion of the photoreceptor and formed by a reference optical scanning device selected from the plurality of optical scanning devices; and first position variable patterns formed by optical scanning devices except for the reference optical scanning device so that main-scan directional error amounts gradually vary along the sub-scan direction on the basis of the formation positions of the first reference test patterns.

[0017] Preferably, the test patterns comprise: second reference test pattern horizontally formed at predetermined intervals apart from each other along the sub-scan direction of the photoreceptor by the reference optical scanning device; and second position variable patterns formed by optical scanning devices except for the reference optical scanning device so that sub-scan directional error amounts gradually vary along the sub-scan direction on the basis of the formation positions of the second reference test patterns.

[0018] Preferably, the photoreceptor is moved slower than a speed set upon normal printing, during the steps (a) through (d) for calculating a color registration error amount.

[0019] For a better understanding of the invention, and to show how embodiments of the same may be carried into effect, reference will now be made, by way of example, to the accompanying diagrammatic drawings in which:

Figure 1 is a cross-sectional view of the engine of a general liquid electrophotographic printer;

Figure 2 is a block diagram of a printer according to the present invention;

Figure 3 is a cross-sectional view illustrating the arrangement relationship between the printing engine and the pattern position detection sensor unit of Figure 2;

Figure 4 is a cross-sectional view illustrating another arrangement relationship between the printing engine and the pattern position detection unit of a printer according to the present invention;

Figure 5 is a cross-sectional view illustrating an example of the concrete configuration of the pattern position detection unit of Figure 2;

Figure 6 is a flowchart illustrating a method of correcting a color registration error, according to the present invention;

Figure 7 is a graph showing the waveforms of sensor outputs corresponding to images of different colors when test pattern of different colors are developed with corresponding color developing materials;

Figure 8 is a perspective view of part of the printing engine of Figures 3 and 4 for illustrating the operation of the printing engine and the cause of a color registration error depending on the operation of the printing engine;

Figure 9 is a block diagram of an example of a main scan directional color registration error detection test pattern which is applied to the present invention;

Figures 10A and 10B are flowcharts illustrating a process for correcting a main scan directional color registration error using the test pattern of Figure 9;

Figure 11 is a block diagram of an example of a sub-scan directional color registration error detection test pattern which is applied to the present invention;

Figure 12 is a block diagram of a still another example of a color registration error detection test pattern which is applied to the present invention;

Figures 13A and 13B are flowcharts illustrating a process for correcting a color registration error using the test pattern of Figure 12; and

Figure 14 is a plan view showing the alignment of polygonal rotating mirrors which rotate at normal speed within optical scanners, to illustrate a process for correcting a generated sub-scan directional color registration error.

[0020] Figure 2 is a block diagram of a printer according to the present invention. The same reference numerals as those in Figure 1 denote the same components.

[0021] Referring to Figure 2, the printer includes a main controller 110, a manipulation panel 120, a display device 130, an engine controller 40, a pattern data storage unit 150, a color registration error correction amount calculator 160, a pattern position detection unit 170, and a printer engine 180.

[0022] The printing engine 180 has mechanical devices which are controlled by the engine controller 140 to print a desired image on paper.

[0023] Referring to Figures 3 and 4 showing a liquid electrophotographic printer engine, the printer engine 180 includes a photoreceptor belt 14, a reset device 15, optical scanning devices 30, 40, 50 and 60, optical detectors 38, 48, 58 and 68, developing devices 36, 46, 56 and 66, a drying device 18, and a transfer device 20. The photoreceptor belt 14 circulates along a path formed by a plurality of rollers 11, 12 and 13. Reference numeral 25 is a cleaning device for cleaning test patterns.

[0024] The first through fourth optical scanning devices 30, 40, 50 and 60 are controlled by the engine controller 140, and project pieces of color information associated with colors of yellow, magenta, cyan and black to the photoreceptor belt 14, respectively.

[0025] The first through fourth developing devices 36, 46, 56 and 66 supply yellow, magenta, cyan and black developers Y, M, C and BK to the photoreceptor belt 14, respectively.

[0026] The main controller 110 decodes print data transmitted from a user computer 200 via a communications interface, converts the decoded data into a bitmap image data suitable for driving the printer engine 180, and transmits the resultant data to the engine controller 140. The main controller 110 processes a signal input from the manipulation panel 120, and controls the display device 130 to display information.

[0027] The manipulation panel 120 is provided with a plurality of keys with which the functions of the printer can be selected. Preferably, a diagnosis key 121 for commanding execution of a color registration error diagnosing mode is provided on the manipulation panel 120.

[0028] The engine controller 140 controls all operations of the printer engine 180 to print an image corresponding to the bitmap image data transmitted from the main controller 110, during normal printing. When the engine controller 140 is commanded to execute the color registration error diagnosing mode by the main controller 110 through the manipulation of the diagnosis key 121, it controls the printer engine 180 so that test patterns recorded in the pattern data storage unit 150 can be formed on the photoreceptor belt 4. When correction data associated with the results of the formation of the test patterns is output from the color registration correction amount calculator 160, the engine controller 140 corrects control timing data associated with the image formation accomplished by the printer engine 180 using this correction data.

[0029] The pattern position detection unit 170 includes a first sensor 171, a first optical source 172, a second sensor 173, and a second optical source 174.

[0030] Each of the first and second sensors 171 and 173 photographs an image within its camera window view and outputs an electrical signal corresponding to the photographed image. CCD can be applied as both the first and second sensors 171 and 173.

[0031] The first and second optical sources 172 and 174, for increasing the image pickup sensitivities of the first and second sensors 171 and 173, are installed capable of projecting light toward the pickup object positions of the first and second sensors 171 and 173. Preferably, the color registration correction amount calculator 160 controls the light emission amounts of the first and second optical sources 172 and 174 using signals output from the sensors 171 and 173. The light emission amounts of the first and second optical sources 172 and 174 are controlled so that voltage levels output from the sensors 171 and 173 in response to received light are constant with respect to portions on which an image is not formed.

[0032] The first and second sensors 171 and 173 and the first and second optical sources 172 and 174 can be installed at any position facing the transmission path for a completely-formed image. The first and second sensors 171 and 173 and the first and second optical sourc-

es 172 and 174, for example, can be installed opposite to the photoreceptor belt 14 between the drying device 18 and the transfer device 20 as shown in Figure 3, or can be installed opposite to the transfer roller 21 as shown in Figure 4.

[0033] Also, as shown in Figure 5, it is preferable that a light focusing lens 175 for focusing light emitted from the pickup object areas on the sensors 171 and 173 is installed between the sensors 171 and 173 and the pick-up object areas. Reference numeral 181 is a main frame, reference numeral 176 is a sensor board, and reference numeral 177 is an optical source supporting board.

[0034] Signals output from the first and second sensors 171 and 173 in response to received light are output to the color registration correction amount calculator 160 via an amplifier (AMP) and comparators 178 and 179.

[0035] The color registration correction amount calculator 160, as a color registration correction means, receives test pattern data applied to detect a color registration error by being interfaced with the engine controller 140, and calculates the amount of a color registration error by comparing the test pattern position information output from the first and second sensors 171 and 173 with the pattern data. Also, the color registration correction amount calculator 160 outputs correction data for correcting the calculated error amount to the engine controller 140.

[0036] The process for correcting a color registration error of a printer will now be described in more detail referring to Figure 6.

[0037] First, a determination is made as to whether there is a command for a color registration diagnosing mode, in step 300. If it is determined in step 300 that there is a command for a color registration diagnosing mode, the test pattern data for each color set for color registration error detection is read from the pattern data storage unit 150, and the operations of the optical scanning devices 30, 40, 50 and 60 are controlled so that an electrostatic latent image corresponding to the read test pattern data can be formed on the photoreceptor belt 14, in step 310.

[0038] The electrostatic latent image formed by the optical scanning devices 30, 40, 50 and 60 on the photoreceptor belt 14 is developed by a selected developing device, preferably, the fourth developing device 66 for supplying a black developer (BK), in step 320.

[0039] The position information between the test patterns formed on the photoreceptor belt 14 is detected by the first and second sensors 171 and 173, in step 330.

[0040] The color registration correction amount calculator 160 calculates the amount of color registration error corresponding to the difference between the position value of the applied test pattern data and the detected position value of the test pattern, in step 340.

[0041] When the calculated error amount is determined to be zero in step 350, the execution of the color registration diagnosis is concluded with the determination that no color registration error exists.

[0042] When it is determined in step 350 that there is a certain amount of error, correction data suitable for color registration error is calculated and output to the engine controller 140, in step 360. The engine controller 140 corrects data related to engine control for image formation using the received correction data. Subsequent image formation accomplished by the printer engine 180 is based on the corrected engine control related data.

[0043] Preferably, the above-described process is repeated until the error amount is determined to be zero.

[0044] In this color registration error correcting process, electrostatic latent images, formed on the photoreceptor belt 14 in response to test pattern data by the optical scanning devices 30, 40, 50 and 60 used to project information of different colors, are developed with a single color, for example, a black developer (BK). This case has the following advantage. When the electrostatic latent images formed by the optical scanning devices 30, 40, 50 and 60 are developed with developers of different colors, the output signals of the first and second sensors 171 and 173 vary according to the color of each test pattern on the basis of a background level corresponding to light incident from areas of the photoreceptor belt 14 on which no image is formed, as shown in Figure 7. Such a result makes it difficult to accurately detect the positions of the test patterns of different colors, or requires a more complicated circuit to accomplish accurate position detection. However, when the test patterns are developed with a single color as in the present invention, accurate image detection determination can be made from the output signals of the first and second sensors 171 and 173, and the configuration of a circuit therefor is simplified.

[0045] The color registration error correcting process will also be seen in association with the operation of the printer engine 180, with reference to Figure 8.

[0046] When the leading edge of a page area set on the photoreceptor belt 14 reaches the scanning line (L_1) of the first optical scanning device 30, yellow color image information scan for one line is initiated after a delay time determined in synchronization with a pulse signal output from the first optical detector 38 in response to received light of projected light. Here, the determined delay time corresponds to the time from the drop point of time of the pulse signal corresponding to the time the projected light reaches the edge of the photoreceptor belt 14, until a polygonal rotating mirror 32 rotating at constant speed is rotated at an angle capable of reflecting light emitted from the optical source 31 toward the leading edge of a given image writing area (D). After the image information scan for one line, light emission is paused. When the next reflective facet of the rotating multi-faceted mirror 32 is situated to be capable of reflecting light, light is emitted until a pulse signal is output from the optical detector 38. After a pulse signal is output

from the optical detector 38, light emission is paused during the determined delay time, and the image information for another line is then scanned.

[0047] The second optical scanning device 40 scans the image information for a magenta color by the same method as the above-described driving method of the first optical scanning device 30, after the photoreceptor belt 14 moves a distance (d_1) from the scan line (L_1) of the first optical scanning device 30, at which the page area set on the photoreceptor belt 14 arrives, to the scan line (L_2) of the second optical scanning device 40.

[0048] The third and fourth optical scanning devices 50 and 60 form images of cyan color information and black color information by the same method as the driving method of the first optical scanning device 30, respectively, when the leading edge of the set page area reaches the scan lines L_3 and L_4 thereof. Reference numerals 41, 51 and 61 are optical sources, reference numerals 42, 52 and 62 are rotating multi-faceted mirrors, and reference numerals 33, 43, 53 and 63 are lens units.

[0049] In this image formation method, the image information for each color sequentially scanned by the optical scanning devices 30, 40, 50 and 60 may be registered out of given pixels on one page area set on the photoreceptor belt 14. In this case, a color registration error must be corrected.

[0050] Figure 9 shows an example of test patterns which are applied to correct a color registration error with respect to the main scan direction (a direction perpendicular to the traveling direction of the photoreceptor belt 14) being a direction in which light is projected, among color registration errors. Reference characters BK, Y, M and C denote patterns formed by the fourth, first, second, and third optical scanning devices 60, 30, 40, and 50, respectively. All of these patterns are developed with the black developer of the fourth developing device 66. Test pattern data are set to be aligned in strips at predetermined intervals in the sub-scan direction on main scan directional image writing start and close positions P1 and P2 on the image writing area D.

[0051] A process for correcting a main scan directional color registration error through this test pattern formation process will now be described referring to Figures 10A and 10B.

[0052] First, when it is determined in step 410 that there is a command for execution of a color registration diagnosing mode, rollers 11, 12 and 13 and rotating multi-faceted mirrors 32, 42, 52 and 62 are driven, in step 420. Here, it is preferable that the photoreceptor belt 14 rotates at a constant speed set lower than a speed set upon normal printing in order to increase the accuracy of measurement. When it is determined in step 430 that the photoreceptor belt 14 and the rotating multi-faceted mirrors 32, 42, 52 and 62 of the optical scanning devices 30, 40, 50 and 60 rotate at the set speed, the optical scanning devices 30, 40, 50 and 60 are driven to form electrostatic latent images corresponding to the test pattern data in a first pattern portion 151 in FIG 9, using the output signals of the optical detectors 38, 48, 58 and 68 in response to light received thereby. That is, when the page area set on the photoreceptor belt 14 reaches the scan line (L_1), the first optical scanning device 30 projects light corresponding to test pattern data after a predetermined delay time corresponding to the time from the drop point of time of the pulse signal of the optical detector 38 corresponding to the end of light reception by the optical detector 38, to the initiation of a main scan directional line image. The second through fourth optical scanning devices 40, 50 and 60 project light corresponding to test pattern data using the output pulse signals of the optical detectors 48, 58 and 68 after page synchronous generation times as delay times initially set for the time from when the page area set on the photoreceptor belt 14 reaches the scan line L_1 of the first optical scanning device 30 to when the page area reaches the respective scan lines L_2, L_3 and L_4.

[0053] Test pattern electrostatic latent images formed by the optical scanning devices 30, 40, 50 and 60 on the photoreceptor belt 14 are developed by the fourth developing device 66 in step 440.

[0054] The position information of these test patterns is detected by the second sensor 173 in step 450.

[0055] When the fourth optical scanning device 60 is selected as a reference optical scanning device, the color registration correction amount calculator 160 calculates the main scan directional error amounts of test patterns Y, M and C formed by the optical scanning devices 30, 40 and 50 on the basis of the position of a test pattern BK formed by the fourth optical scanning device 60, in step 460. That is, the error amounts of the distances X_{1Y}, X_{1M} and X_{1C} between the edge of the belt 14 and each of the patterns Y, M and C formed by the optical scanning devices 30, 40 and 50 are calculated on the basis of the distance X_{1BK} between the edge of the belt 14 and the reference pattern BK. A determination of whether an image writing start position is consistent with a reference position is made on the basis of the calculated error amount, in step 470. If it is determined in step 470 that a certain amount of error exists, data related to image scan initiation is corrected, in step 480. Then, steps 440 through 470 are repeated.

[0056] On the other hand, if it is determined in step 470 that no error exists, a second pattern portion 152 is formed on the photoreceptor belt 14, in step 510. In step 510, the corrected first pattern portion 151 can be formed on the photoreceptor belt 14 together with the second pattern portion 152 to be corrected.

[0057] Through steps 520 and 530, it is calculated how the line widths X_{2Y}, X_{2M} and X_{2C} of the patterns Y, M and C formed by the optical scanning devices 30, 40 and 50 are deviated from the image writing line width X_{2BK} between the image writing start and close positions P1 and P2 of the reference pattern BK. Then, it is determined whether there is a certain amount of error, in step 540. If it is determined in step 540 that a certain amount of error exists, inter-pixel image scan time con-

trol data is corrected, in step 550. Thereafter, steps 510 through 540 are repeated.

[0058] On the other hand, after step 430, the first and second pattern portions 151 and 152 are formed together on the photoreceptor belt 14, and all of the image writing start position P1 and the image writing line widths can be calculated and corrected.

[0059] Meanwhile, a color registration error with respect to a sub-scan direction (a direction perpendicular to the main scan direction) can be corrected by calculating the error amount from the inter-pattern position information with respect to the sub-scan direction output from the sensors 171 and 173 using test patterns shown in Figure 11. In this case, the data for controlling the sub-scanning is corrected to make the distance between the test patterns constant.

[0060] Also, the test patterns of Figure 9 and those of Figure 11 can be formed together on the photoreceptor belt 14 through one printing process, in order to calculate the color registration errors with respect to both the main scan direction and the sub-scan direction.

[0061] Still another test pattern and a color registration error correcting process using the same are shown in Figures 12 and 13.

[0062] Referring to Figure 12, first reference test patterns 153 are aligned at predetermined intervals along the sub-scan direction on the main scan directional image writing start position P1 corresponding to one edge of the image writing area D set in the middle of the photoreceptor belt 14 for the fourth optical scanning device 60 selected as a reference optical scanning device. First position variable patterns 154 are formed by optical scanning devices to be inspected, that is, the first through third optical scanning devices 30, 40 and 50, at positions where a main scan directional error amount gradually increases and decreases from negative to positive by unit values set along the sub-scan direction on the basis of where the first reference test patterns 153 are formed. According to the example shown in Figure 12, the main scan directional error component of the first position variable pattern 154 on a sixth block is set to be zero with respect to the first reference test pattern 153. The test patterns 153 and 154 are formed so that the error amounts of the variable test patterns 154 can gradually vary as it moves farther from the sixth block.

[0063] Accordingly, if only the block on which the first reference test pattern 153 is formed on the same position as the position of the first position variable pattern 154 is detected from the position information of the test patterns subsequently detected by the second sensor 173, image scan initiation time control data with respect to the main scan direction for the optical scanning devices 30, 40 and 50 can be corrected. Second reference test patterns 155, formed by the reference optical scanning device 60 selected to correct a sub-scan directional color registration error, are horizontally formed predetermined intervals apart from each other along the sub-scan direction of the photoreceptor belt 14. Second position variable patterns 156 formed by the optical scanning devices 30, 40 and 50 to be inspected are formed one by one along the sub-scan direction on positions where a sub-scan directional error amount gradually increases or decreases from negative to positive by set unit values on the basis of where the second reference test patterns 155 are formed. Then, the block on which the two patterns 155 and 156 are formed on the same position is detected by the above-described method, and control data for sub-scan directional image scan initiation time of the optical scanning devices 30, 40 and 50 can thus be compensated by an error amount applied to the detected block.

[0064] In case that the test patterns of Figure 12 are used, it is preferable that the color registration error amount of one of the optical scanning devices 30, 40 and 50 to be detected is calculated through one printing process. Figures 13A and 13B illustrate a process for correcting the color registration error of each of the optical scanning devices 30, 40 and 50 on the basis of the reference optical scanning device 60.

[0065] The main scan directional color registration error correction among the optical scanning devices 30, 40, 50 and 60 is accomplished by internally correcting the delay time from generation of a pulse signal from each of the optical detectors 38, 48, 58 and 68 in response to received light to image information scan initiation, and the scan interval for each pixel data so that the same number of pieces of pixel information can be registered on set positions within a set image line width. On the contrary, sub-scan directional color registration error correction between optical scanning devices 30, 40, 50 and 60 is accomplished by alignment adjustment between rotating multi-faceted mirrors 32, 42, 52 and 62 or scan disks (not shown: on which hologram patterns are formed to deflect incident light by rotation) applied as optical deflecting means of the applied optical scanning devices 30, 40, 50 and 60. That is, as shown in Figure 14, an alignment angle (a) corresponding to the stagger degree between the reflective facet of the rotating multi-faceted mirror 62 of the reference optical scanning device 60 and that of each of the rotating multi-faceted mirrors 32, 42 and 52 of the optical scanning devices 30, 40 and 50 having a sub-scan directional registration error must be controlled. This alignment control data is obtained from the color registration correction amount calculator 160 according to the calculated sub-scan directional error amount. The engine controller 140 drives the rotating multi-faceted mirrors 32, 42, 52 and 62 at equal speeds according to the correction amount so that the reflective facet of the reference rotating multi-faceted mirror 62 and those of the remaining rotating multi-faceted mirrors 32, 42 and 52 can maintain an intersecting angle corresponding to the correction amount. At this time, color registration error is corrected.

[0066] According to the printer and the method of correcting a color registration error described above, an image is formed by developing electrostatic latent images

corresponding to test patterns formed on a photoreceptor belt by optical scanning devices with a single color. Therefore, a structure for measuring error amounts from the test patterns is simple, and the accuracy of measurement can be improved.

[0067] The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

[0068] All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

[0069] Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

[0070] The invention is not restricted to the details of the foregoing embodiment(s). The invention extend to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

Claims

1. A printer comprising;

   a photoreceptor (14) circulating along a path formed by a plurality of rollers (11,12,13);

   a plurality of optical scanning devices (30,40,50,60) for scanning light toward the photoreceptor;

   a plurality of developing devices (36,46,56,66) for supplying developing materials of different colors to the photoreceptor;

   a plurality of detectors (38, 48, 58, 68) for detecting part of light emitted from the optical scanning devices;

   an engine controller (140) for controlling the driving of the optical scanning devices, the developing devices, and the rollers using received light output from the optical detectors so that test patterns for each optical scanning device set to detect the color registration error between the optical scanning devices can be formed on the photoreceptor;

   a pattern position detection means (170) for detecting the positions of the test patterns formed from fixed positions through a developing process; and

   a color registration correction means (160) for calculating a color registration error amount from the position information of the test patterns provided by the pattern position detection means, and calculating color registration correction data from the calculated error amount and outputting the calculated correction data to the engine controller.

2. The printer of claim 1, wherein the engine controller (140) controls one selected developing device (66) to develop electrostatic latent images formed on the photoreceptor in response to the test patterns by the optical scanning devices with a single color developing material.

3. The printer of claim 1 or 2, wherein the pattern position detection means (170) comprises:

   first and second pattern position detection sensors (171,173) spaced apart from each other opposite to an image writing surface of the photoreceptor (14); and

   first and second optical sources (172,174) for irradiating light toward the detecting areas of the first and second pattern position detection sensors (171,173).

4. The printer of claim 1 or 2, wherein the pattern position detection means (170) comprises:

   first and second pattern position detection sensors (171,173) spaced apart from each other opposite to a transfer device (21) for transferring an image formed on the photoreceptor (14) to paper (23); and
   first and second optical sources (172,174) for irradiating light toward the detecting areas of the first and second pattern position detection sensors (171,173).

5. The printer of any of claims 1 to 4, wherein a cleaning device (25) for cleaning the completely-developed test patterns is installed at a predetermined position on an image transmission path.

6. A color registration error correcting method for use in a printer having a photoreceptor (14) circulating along a path formed by a plurality of rollers

(11,12,13), a plurality of optical scanning devices (30,40,50,60) for scanning light toward the photoreceptor, and a plurality of developing devices (36,46,56,66) for supplying developing materials of different colors to the photoreceptor, the method comprising the steps of:

(a) forming electrostatic latent images corresponding to test patterns of different colors set for color registration error detection, on the photoreceptor (14) by the optical scanning devices (30,40,50,60);

(b) developing the different color electrostatic latent images with a single color developing material by one selected developing device (66);

(c) detecting (170) the positions of the test patterns formed of the single color developing material;

(d) calculating (160) color registration error amounts from the detected test pattern position information; and

(e) obtaining (160) color registration correction data from the error amounts calculated in step (d).

7. The method of claim 6, further comprising repetition of steps (a) through (d) with the correction data obtained in step (e).

8. The method of claim 6 or 7, wherein the test patterns are set to be aligned on the image writing start and close positions corresponding to the both ends of an image writing area set in the middle portion of the photoreceptor, and predetermined intervals apart from each other along the traveling direction of the photoreceptor.

9. The method of any of claims 6 to 8, wherein the test patterns comprise:

first reference test patterns (153) spaced apart from each other at predetermined intervals along the sub-scan direction on the main-scan directional image writing start position corresponding to one end of the image writing area set in the middle portion of the photoreceptor and formed by a reference optical scanning device (60) selected from the plurality of optical scanning devices; and

first position variable patterns (154) formed by optical scanning devices (30,40,50) except for the reference optical scanning device (60) so that main-scan directional error amounts gradually vary along the sub-scan direction on the basis of the formation positions of the first reference test patterns.

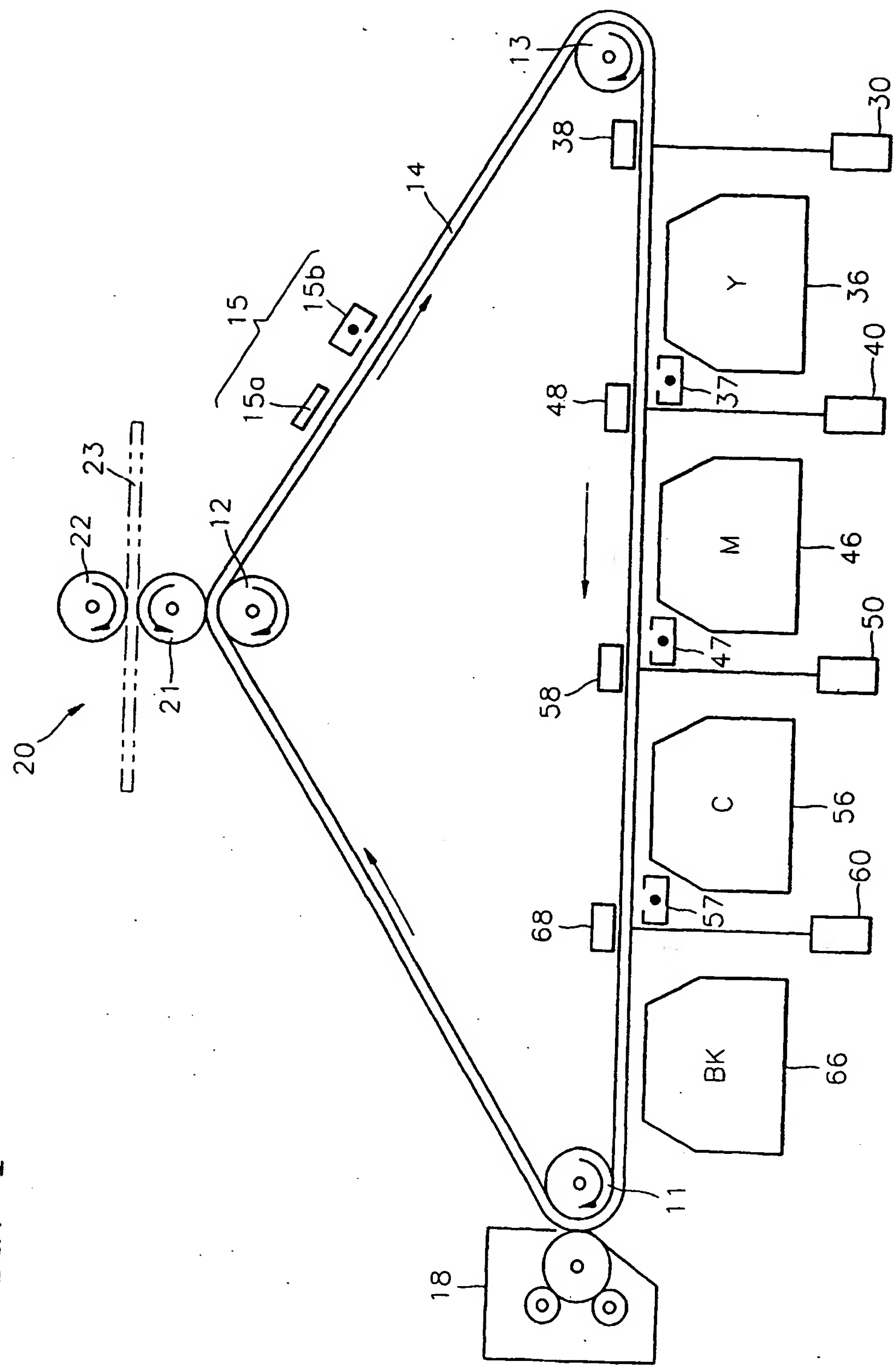
10. The method of any of claims 6 to 9, wherein the test patterns comprise:

second reference test patterns (155) horizontally formed at predetermined intervals apart from each other along the sub-scan direction of the photoreceptor by the reference optical scanning device (60); and

second position variable patterns (156) formed by optical scanning devices (30,40,50) except for the reference optical scanning device (60) so that sub-scan directional error amounts gradually vary along the sub-scan direction on the basis of the formation positions of the second reference test patterns.

11. The method of any of claims 6 to 10, wherein the photoreceptor is moved slower than a speed set upon normal printing, during the steps (a) through (d) for calculating a color registration error amount.

FIG. 1



11
12
13
14
15
15a
15b
18
20
21
22
23
30
36
37
38
40
46
47
48
50
56
57
58
60
66
68
Y
M
C
BK

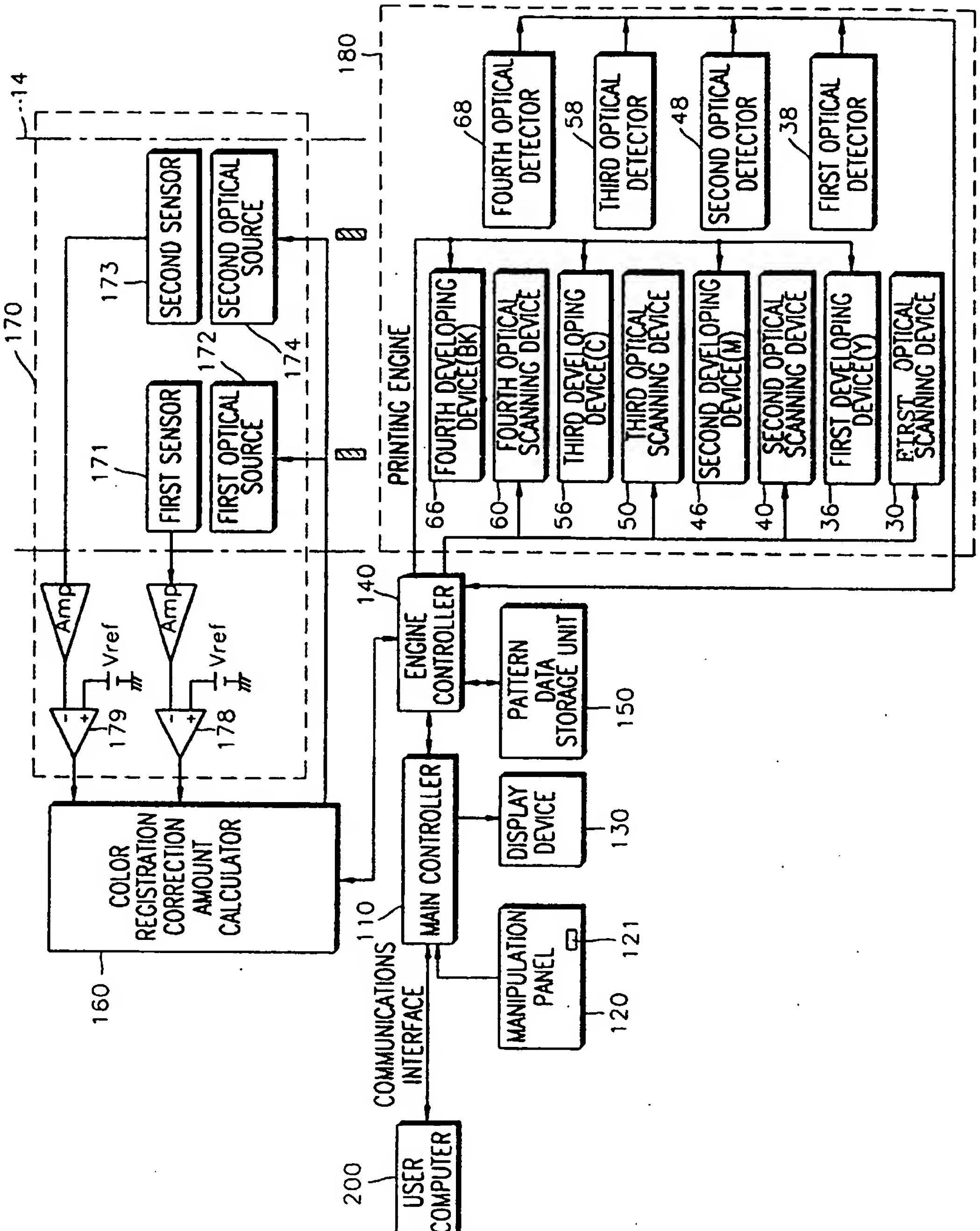
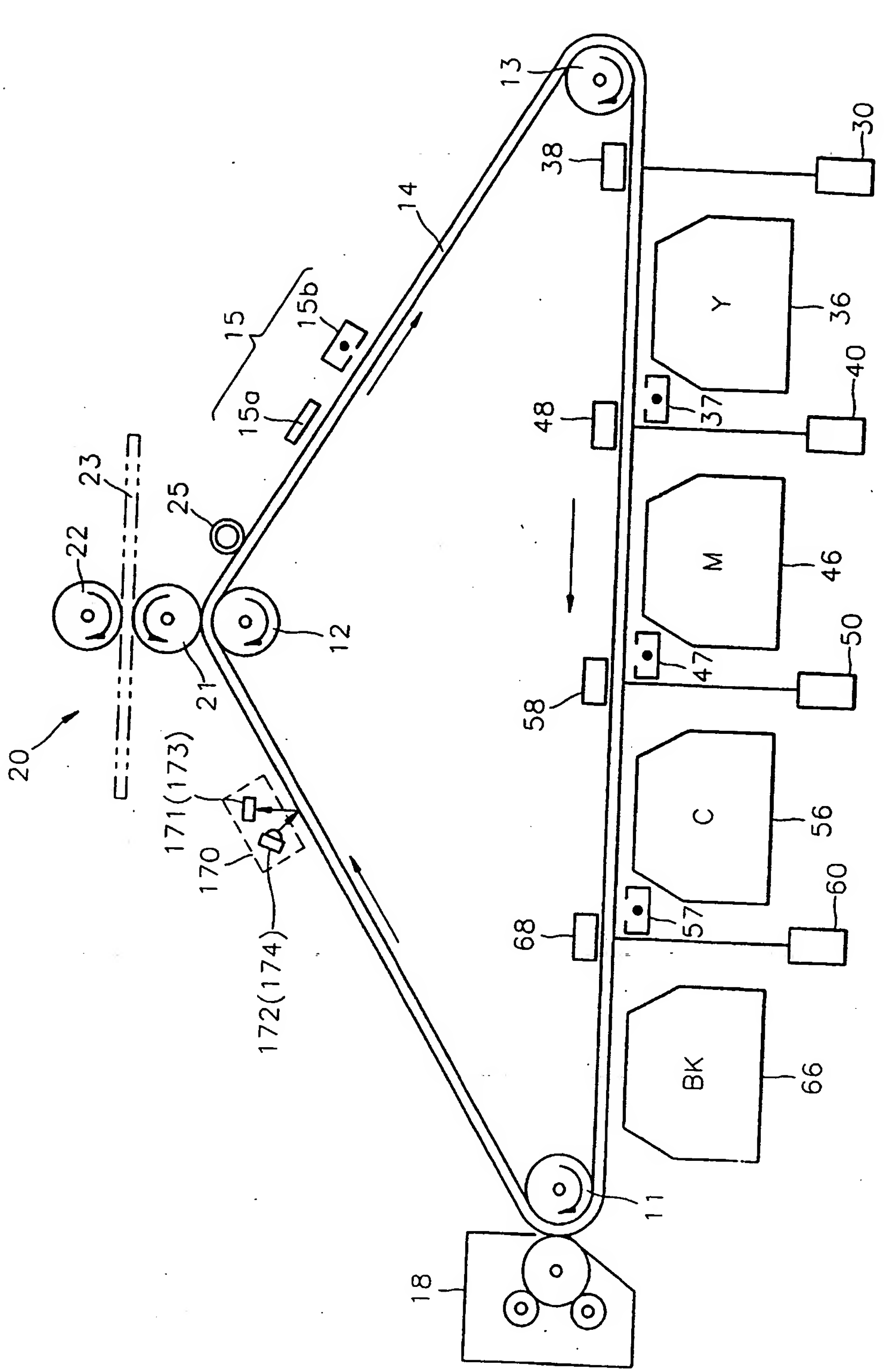

14
170
173
SECOND SENSOR
SECOND OPTICAL SOURCE
174
171
FIRST SENSOR
172
FIRST OPTICAL SOURCE
Amp
Amp
Vref
Vref
179
178
160
COLOR REGISTRATION CORRECTION AMOUNT CALCULATOR
180
PRINTING ENGINE
68
FOURTH OPTICAL DETECTOR
58
THIRD OPTICAL DETECTOR
48
SECOND OPTICAL DETECTOR
38
FIRST OPTICAL DETECTOR
66
FOURTH DEVELOPING DEVICE(BK)
60
FOURTH OPTICAL SCANNING DEVICE
56
THIRD DEVELOPING DEVICE(C)
50
THIRD OPTICAL SCANNING DEVICE
46
SECOND DEVELOPING DEVICE(M)
40
SECOND OPTICAL SCANNING DEVICE
36
FIRST DEVELOPING DEVICE(Y)
30
FIRST OPTICAL SCANNING DEVICE
140
ENGINE CONTROLLER
PATTERN DATA STORAGE UNIT
150
110
MAIN CONTROLLER
DISPLAY DEVICE
130
MANIPULATION PANEL
121
120
COMMUNICATIONS INTERFACE
200
USER COMPUTER

FIG. 2

FIG. 3



13
14
15
15a
15b
22
23
25
20
21
12
171(173)
170
172(174)
11
18
38
30
Y
36
48
37
40
M
46
47
50
58
C
56
57
60
68
BK
66

FIG. 4

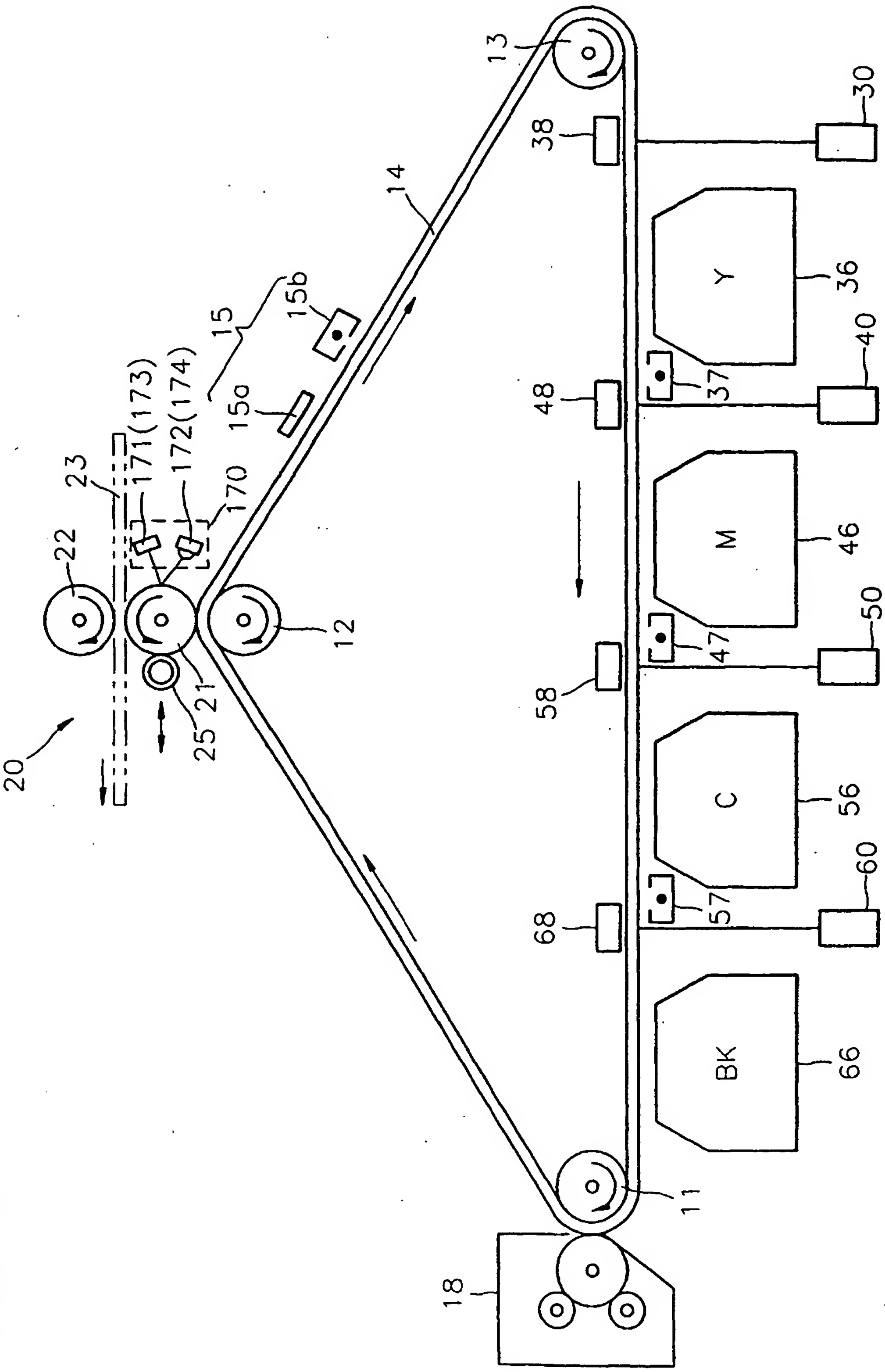

13
14
15
15a
15b
171(173)
172(174)
170
23
22
21
25
20
12
11
18
38
30
Y
36
37
40
48
M
46
47
50
58
C
56
57
60
68
BK
66

FIG. 5

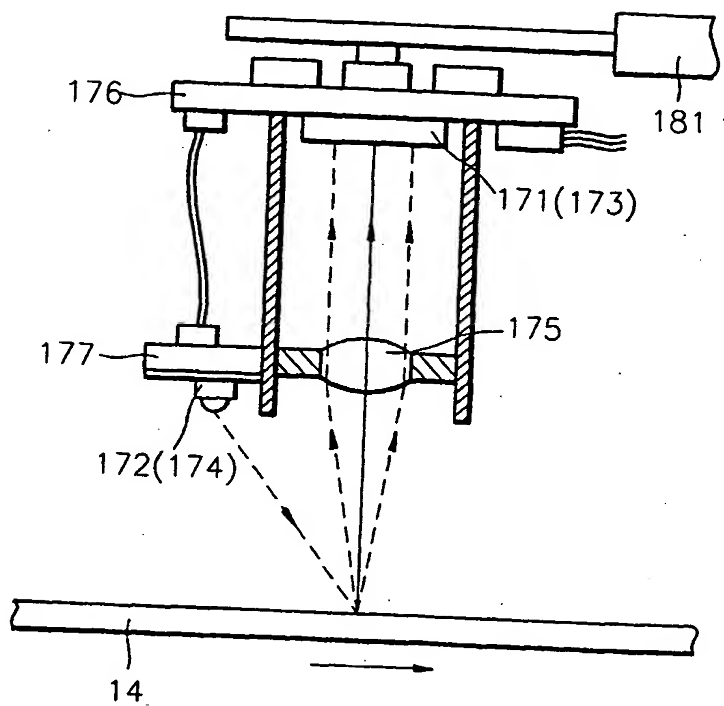


FIG. 6

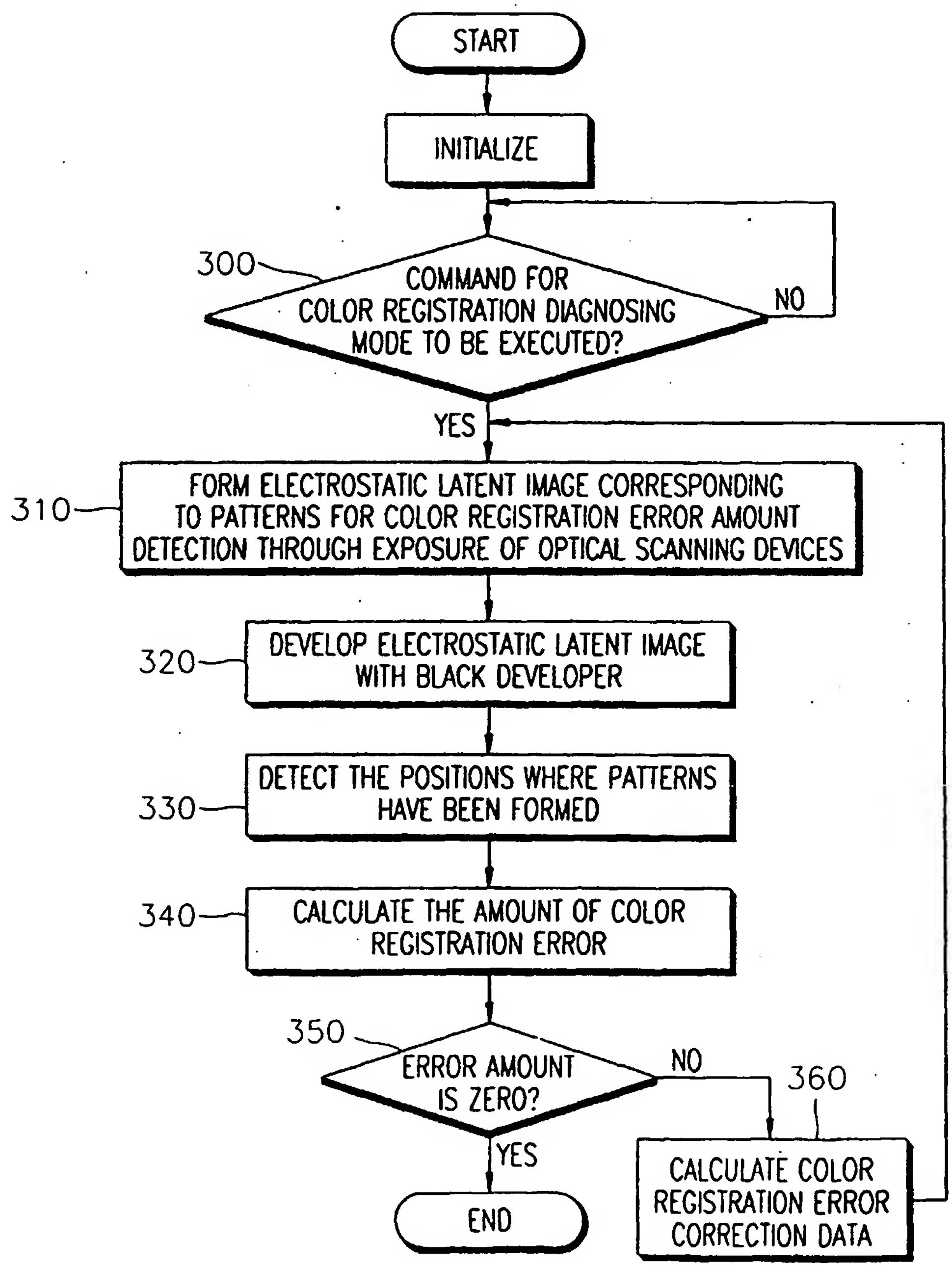
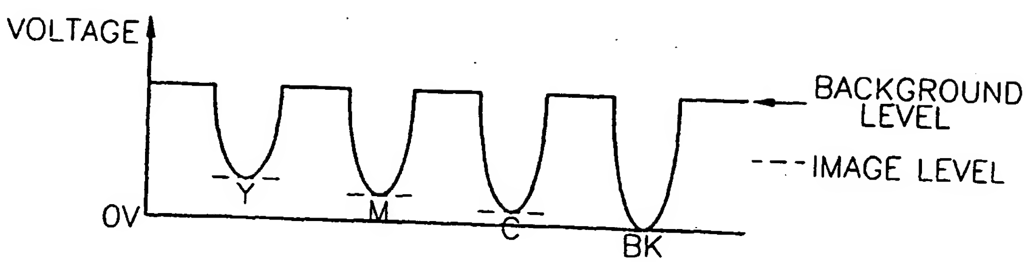

START
INITIALIZE
300
COMMAND FOR COLOR REGISTRATION DIAGNOSING MODE TO BE EXECUTED?
NO
YES
310
FORM ELECTROSTATIC LATENT IMAGE CORRESPONDING TO PATTERNS FOR COLOR REGISTRATION ERROR AMOUNT DETECTION THROUGH EXPOSURE OF OPTICAL SCANNING DEVICES
320
DEVELOP ELECTROSTATIC LATENT IMAGE WITH BLACK DEVELOPER
330
DETECT THE POSITIONS WHERE PATTERNS HAVE BEEN FORMED
340
CALCULATE THE AMOUNT OF COLOR REGISTRATION ERROR
350
ERROR AMOUNT IS ZERO?
NO
360
YES
END
CALCULATE COLOR REGISTRATION ERROR CORRECTION DATA

FIG. 7



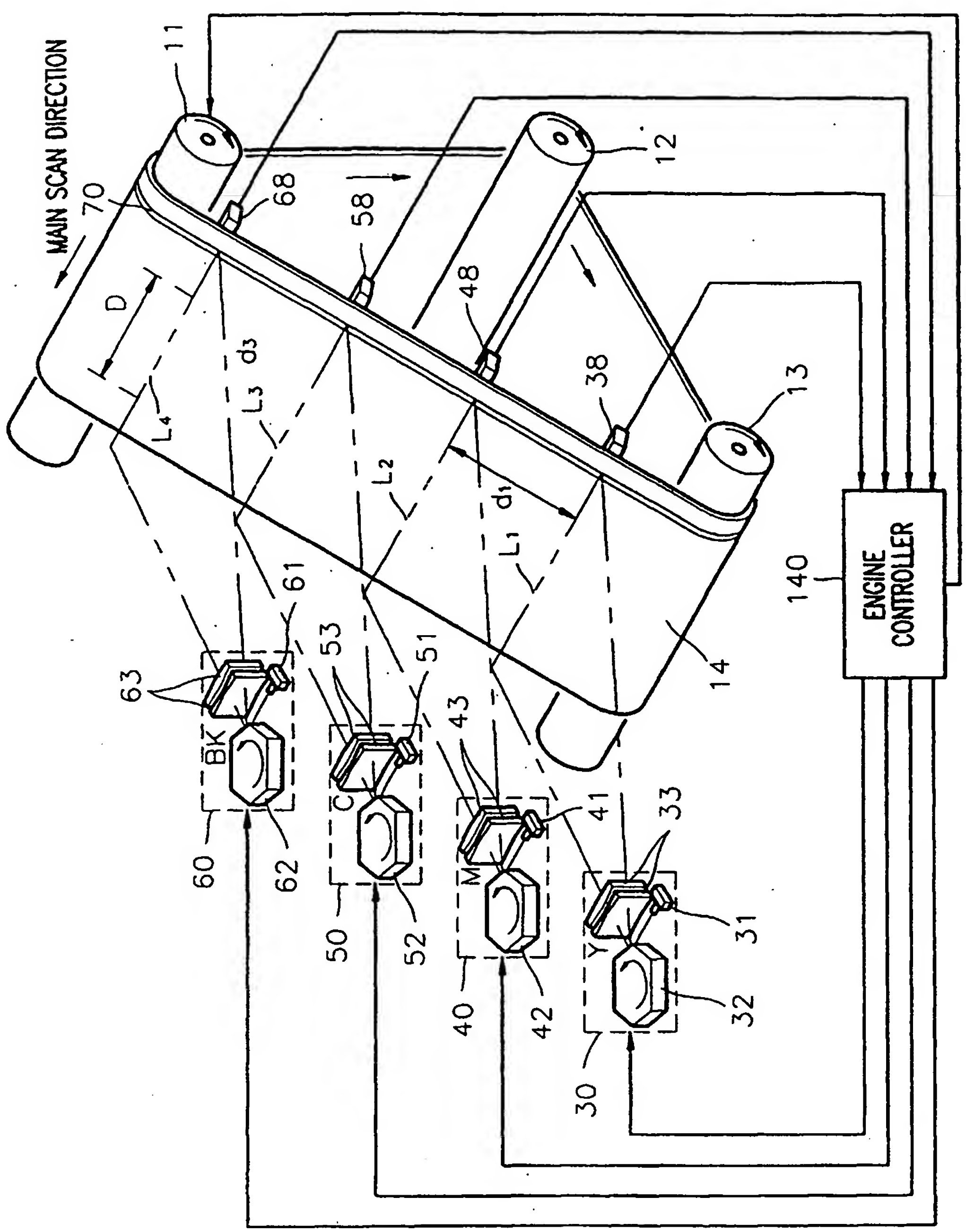

MAIN SCAN DIRECTION
ENGINE CONTROLLER
140
11
12
13
14
70
68
58
48
38
D
d3
d1
L4
L3
L2
L1
63
61
53
51
43
41
33
31
BK
C
M
Y
60
62
50
52
40
42
30
32

FIG. 8

FIG. 9

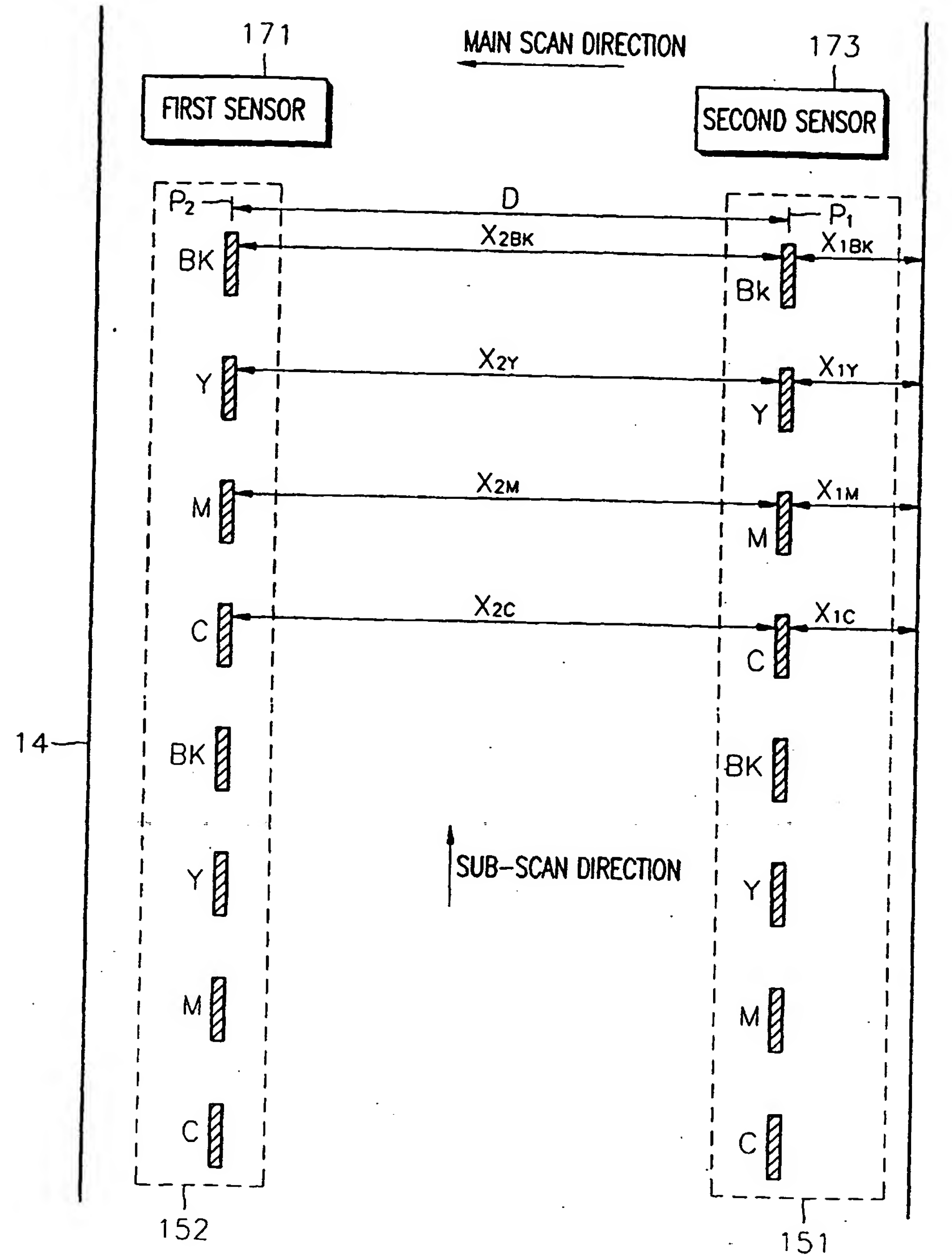

171
MAIN SCAN DIRECTION
173
FIRST SENSOR
SECOND SENSOR
P2
D
P1
X2BK
X1BK
BK
Bk
X2Y
X1Y
Y
Y
X2M
X1M
M
M
X2C
X1C
C
C
14
BK
BK
SUB-SCAN DIRECTION
Y
Y
M
M
C
C
152
151

FIG. 10A

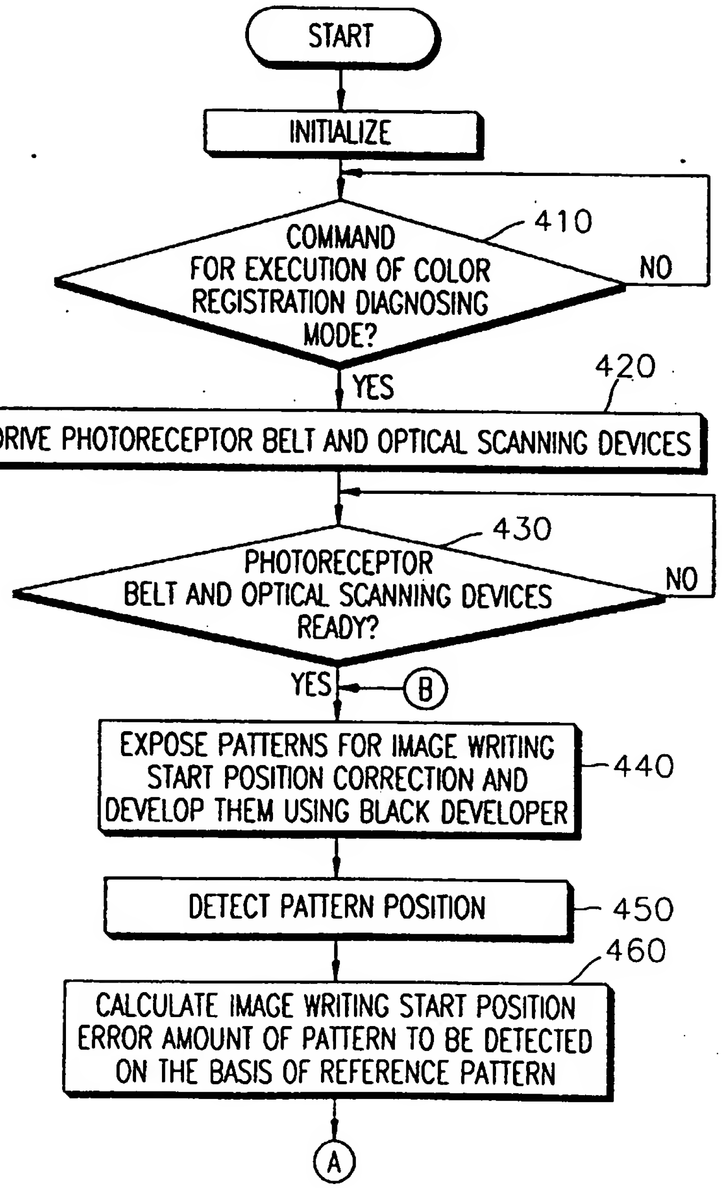

START
INITIALIZE
COMMAND FOR EXECUTION OF COLOR REGISTRATION DIAGNOSING MODE?
410
NO
YES
420
DRIVE PHOTORECEPTOR BELT AND OPTICAL SCANNING DEVICES
430
PHOTORECEPTOR BELT AND OPTICAL SCANNING DEVICES READY?
NO
YES
B
EXPOSE PATTERNS FOR IMAGE WRITING START POSITION CORRECTION AND DEVELOP THEM USING BLACK DEVELOPER
440
DETECT PATTERN POSITION
450
460
CALCULATE IMAGE WRITING START POSITION ERROR AMOUNT OF PATTERN TO BE DETECTED ON THE BASIS OF REFERENCE PATTERN
A

FIG. 10B

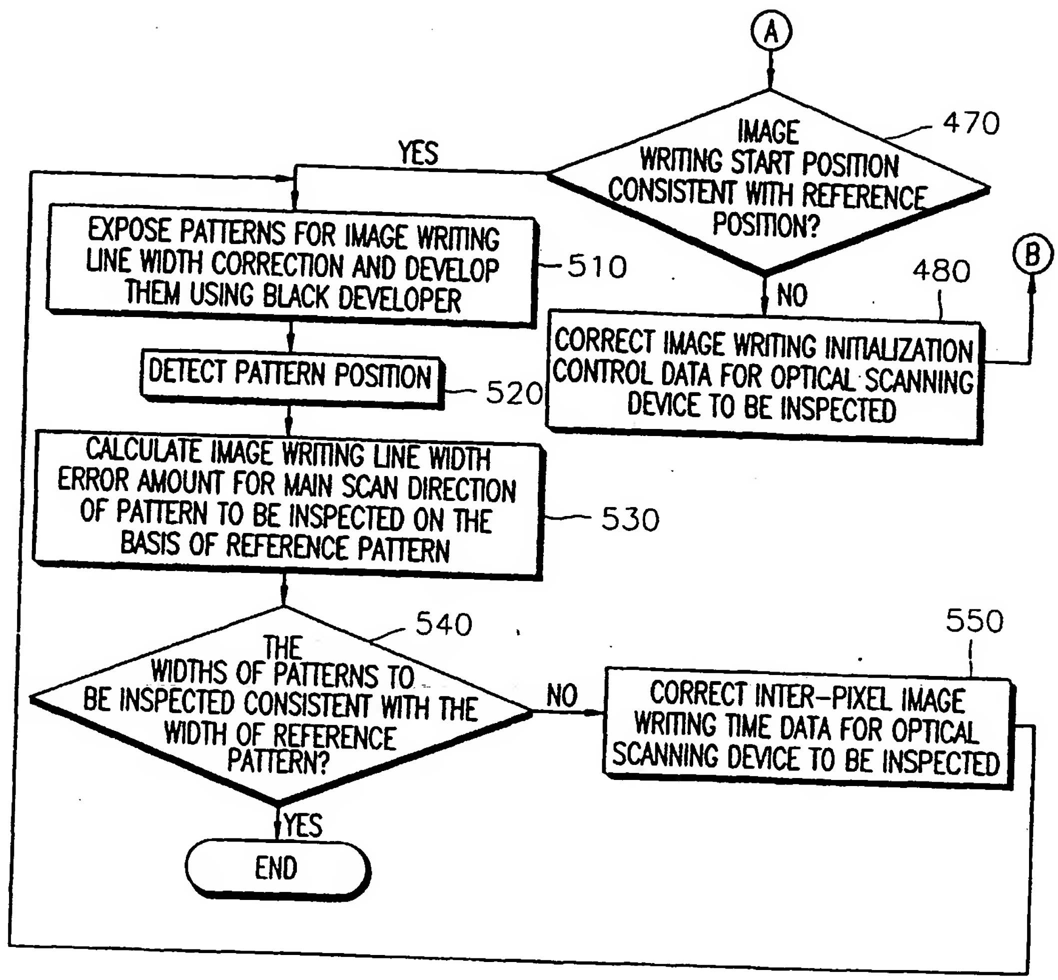

A
IMAGE WRITING START POSITION CONSISTENT WITH REFERENCE POSITION?
470
YES
NO
EXPOSE PATTERNS FOR IMAGE WRITING LINE WIDTH CORRECTION AND DEVELOP THEM USING BLACK DEVELOPER
510
480
B
CORRECT IMAGE WRITING INITIALIZATION CONTROL DATA FOR OPTICAL SCANNING DEVICE TO BE INSPECTED
DETECT PATTERN POSITION
520
CALCULATE IMAGE WRITING LINE WIDTH ERROR AMOUNT FOR MAIN SCAN DIRECTION OF PATTERN TO BE INSPECTED ON THE BASIS OF REFERENCE PATTERN
530
540
550
THE WIDTHS OF PATTERNS TO BE INSPECTED CONSISTENT WITH THE WIDTH OF REFERENCE PATTERN?
NO
CORRECT INTER-PIXEL IMAGE WRITING TIME DATA FOR OPTICAL SCANNING DEVICE TO BE INSPECTED
YES
END

FIG. 11

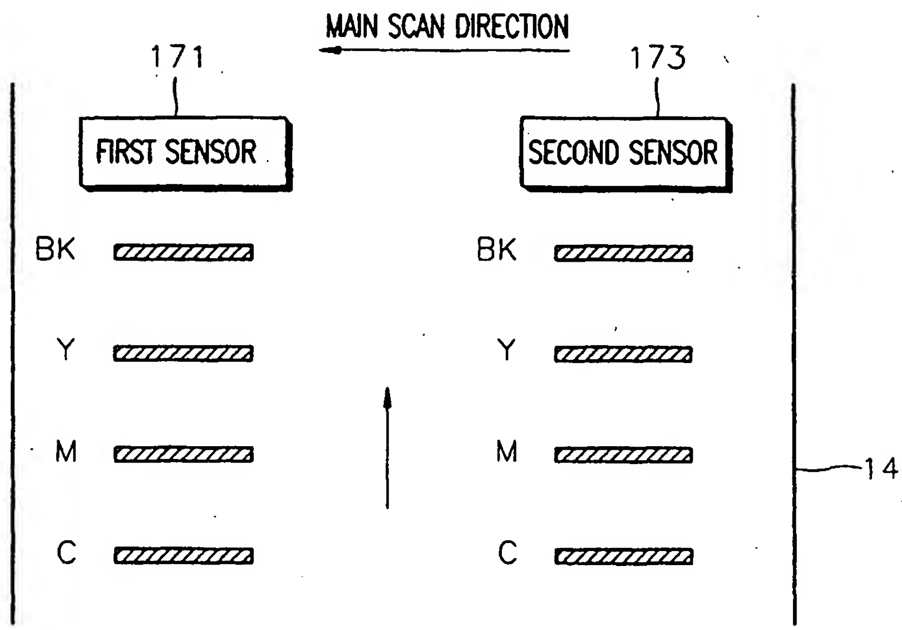

MAIN SCAN DIRECTION
171
173
FIRST SENSOR
SECOND SENSOR
BK
Y
M
C
BK
Y
M
C
14

FIG. 12

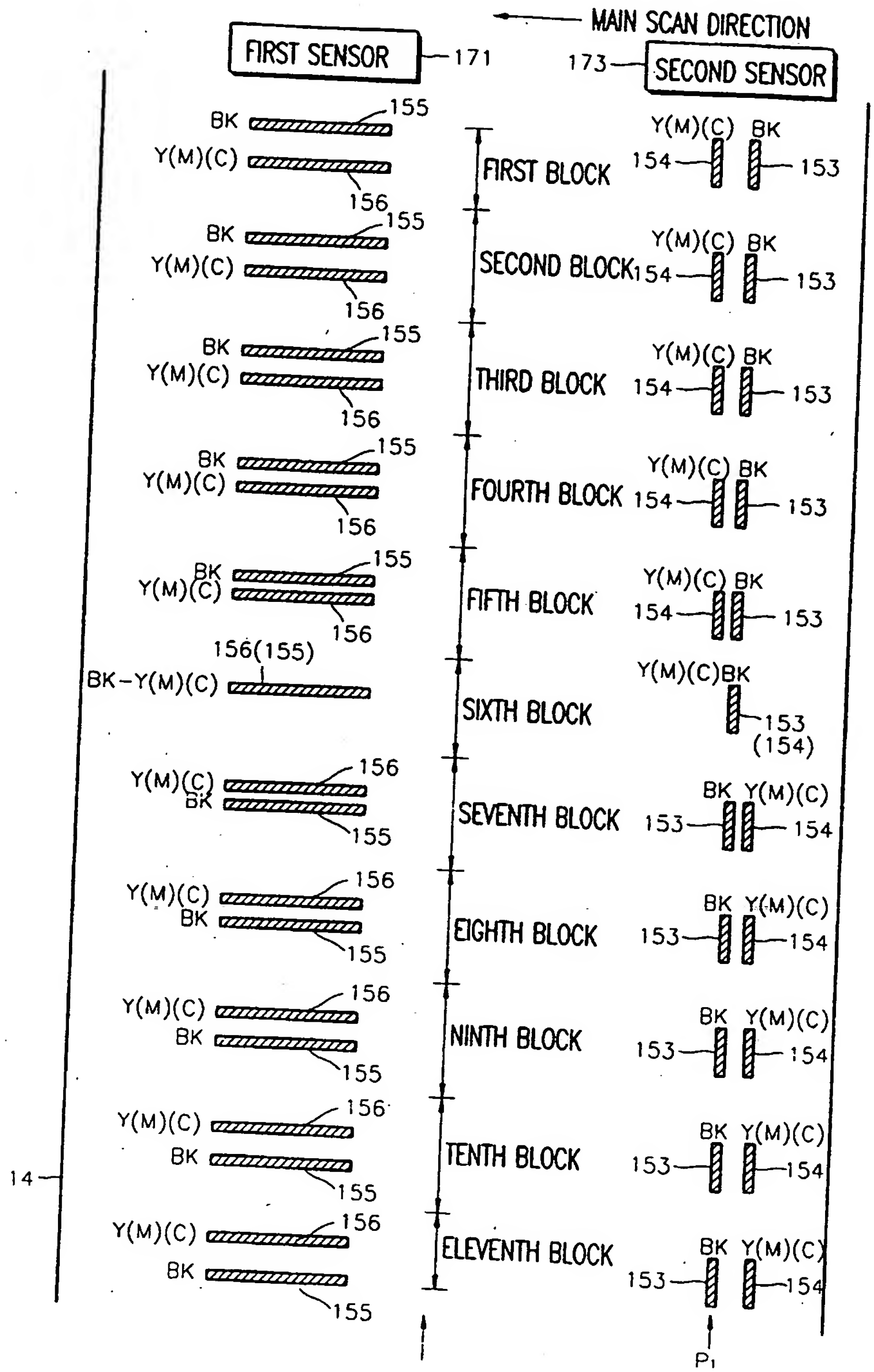

MAIN SCAN DIRECTION
FIRST SENSOR
171
173
SECOND SENSOR
BK
Y(M)(C)
155
156
153
154
FIRST BLOCK
SECOND BLOCK
THIRD BLOCK
FOURTH BLOCK
FIFTH BLOCK
156(155)
BK-Y(M)(C)
SIXTH BLOCK
Y(M)(C)BK
153
(154)
SEVENTH BLOCK
EIGHTH BLOCK
NINTH BLOCK
TENTH BLOCK
ELEVENTH BLOCK
14
P1

FIG. 13A

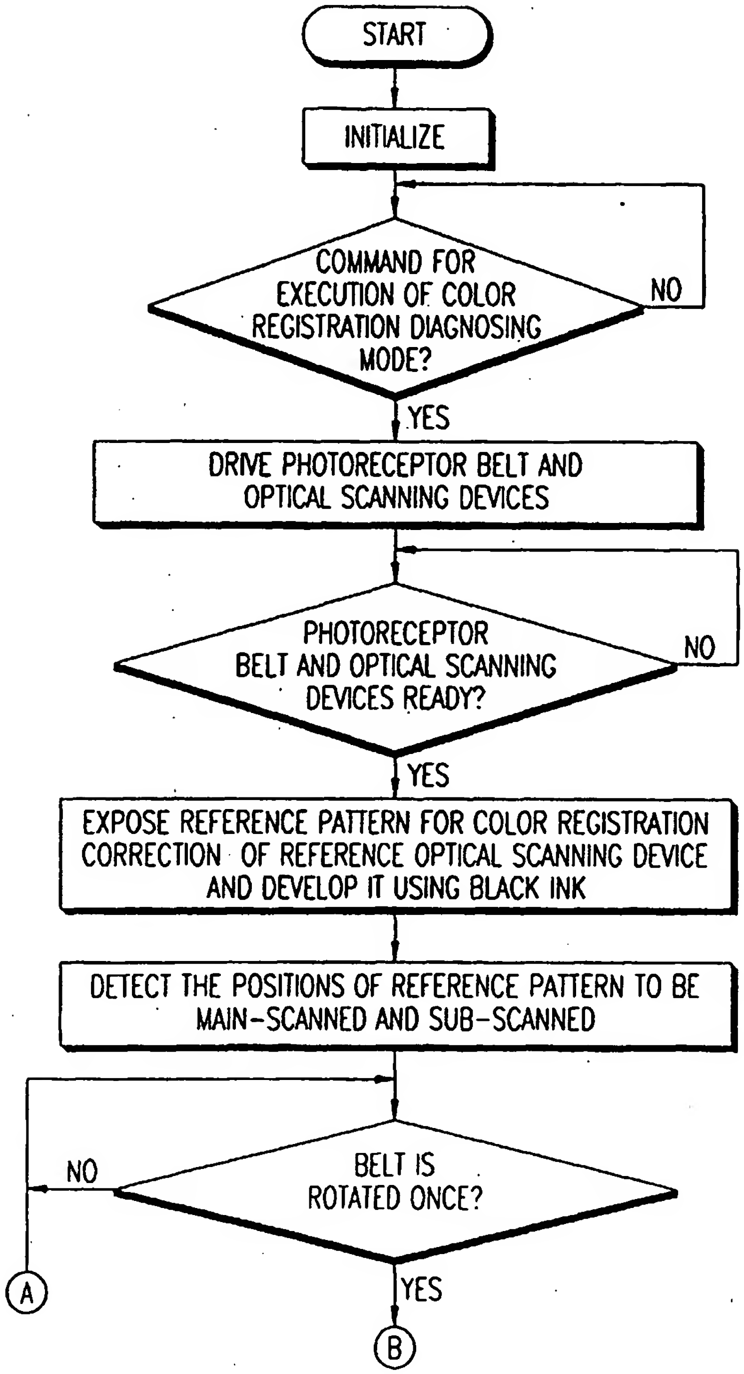

START
INITIALIZE
COMMAND FOR EXECUTION OF COLOR REGISTRATION DIAGNOSING MODE?
NO
YES
DRIVE PHOTORECEPTOR BELT AND OPTICAL SCANNING DEVICES
PHOTORECEPTOR BELT AND OPTICAL SCANNING DEVICES READY?
NO
YES
EXPOSE REFERENCE PATTERN FOR COLOR REGISTRATION CORRECTION OF REFERENCE OPTICAL SCANNING DEVICE AND DEVELOP IT USING BLACK INK
DETECT THE POSITIONS OF REFERENCE PATTERN TO BE MAIN-SCANNED AND SUB-SCANNED
BELT IS ROTATED ONCE?
NO
YES
A
B

FIG. 13B

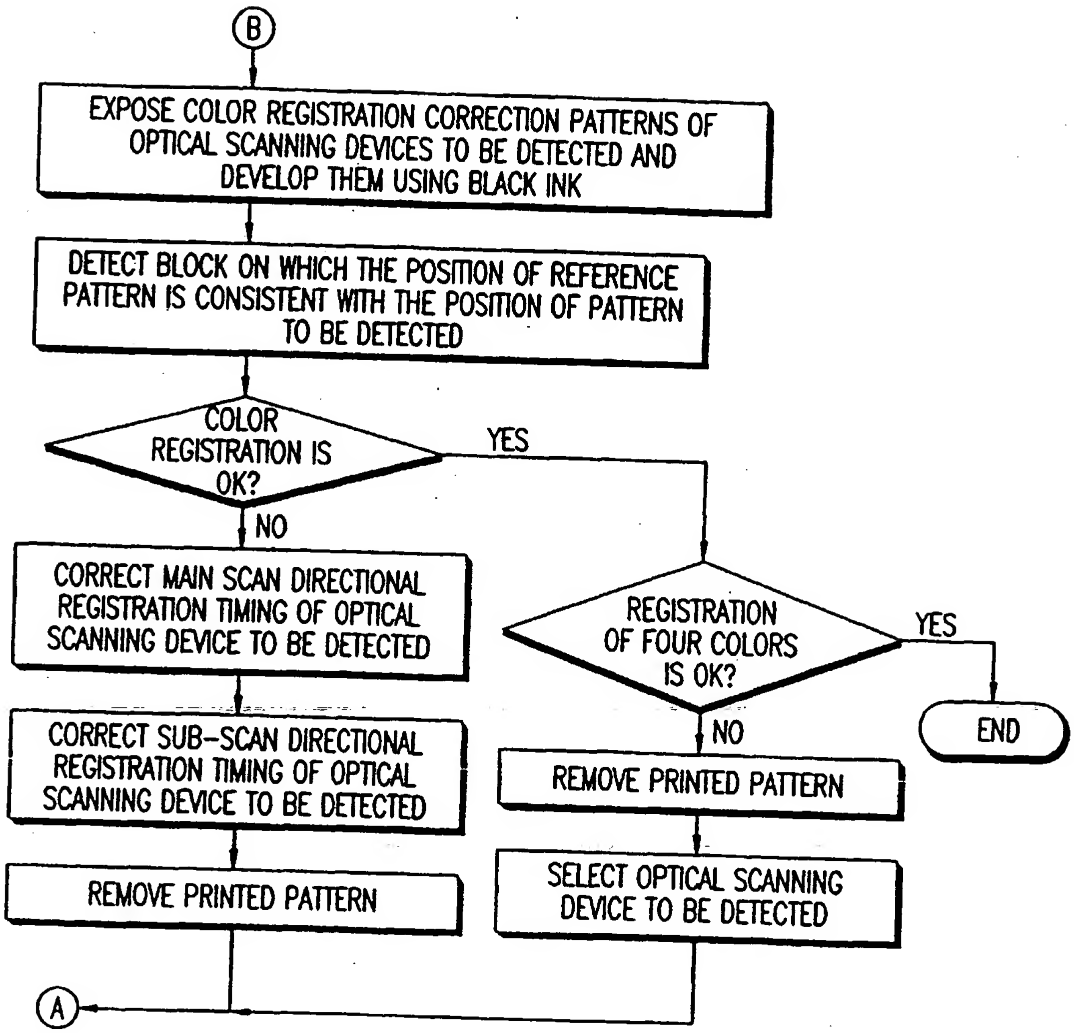

B
EXPOSE COLOR REGISTRATION CORRECTION PATTERNS OF OPTICAL SCANNING DEVICES TO BE DETECTED AND DEVELOP THEM USING BLACK INK
DETECT BLOCK ON WHICH THE POSITION OF REFERENCE PATTERN IS CONSISTENT WITH THE POSITION OF PATTERN TO BE DETECTED
COLOR REGISTRATION IS OK?
YES
NO
CORRECT MAIN SCAN DIRECTIONAL REGISTRATION TIMING OF OPTICAL SCANNING DEVICE TO BE DETECTED
CORRECT SUB-SCAN DIRECTIONAL REGISTRATION TIMING OF OPTICAL SCANNING DEVICE TO BE DETECTED
REMOVE PRINTED PATTERN
REGISTRATION OF FOUR COLORS IS OK?
YES
END
NO
REMOVE PRINTED PATTERN
SELECT OPTICAL SCANNING DEVICE TO BE DETECTED
A

FIG. 14